

Field Repair of Microprocessor-Based Equipment

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This article describes the methods in the Deep Space Network to support the maintenance of microprocessor based devices. This effort is focused on testing by in-circuit emulation and the ability to generate executable microdiagnostics in the field. A further enhancement of this effort is the generation of more comprehensive diagnostics which may be down-loaded from a remote location. This article also points out the need for a change in past training philosophy when dealing with microprocessors.

I. Introduction

In 1971 the Intel Corporation introduced the first microprocessor, the 4004, a 4-bit processor. One year later Intel Corporation introduced the 8008, an 8-bit processor. A major improvement on these two devices resulted in the 4040 and the 8080, which provided external interrupt capabilities necessary for real-time processing. In 1978 Intel Corporation introduced the 8086, a 16-bit processor offering many features and capabilities of minicomputers.

The first microprocessors to appear in the Deep Space Station Tracking Network were (1) a 4040 resident in the Block III Subcarrier Demodulator Assembly Controller and (2), an 8080 resident in the Block IV Receiver/Exciter Controller. Microprocessors currently in use in the Deep Space Network are resident in the following equipments:

- (1) Real-time combiner 8080
- (2) Precision power monitor 8080
- (3) Spectral signal indicator 8080
- (4) Configuration control group 8080
- (5) Hydrostatic bearing monitor 8048
- (6) Digital tone extractor 8085
- (7) Subreflector control assembly Z80
- (8) Block III subcarrier demodulator assembly 4040
- (9) Digital controlled oscillator 8086

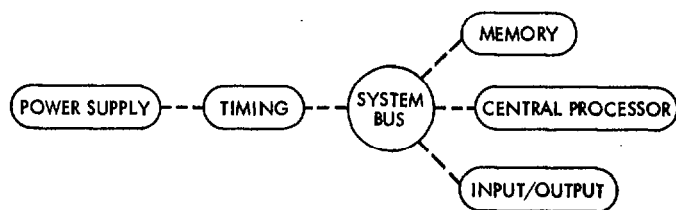
Projected estimates for the Network Consolidation Era include both 8- and 16-bit microprocessors with a combined total usage in excess of 100 controllers at each complex.

II. Background

Prior to the introduction of microprocessors, the Deep Space Station equipment complement included mini and main-frame computers for the purpose of station monitor, telemetry tracking, command processing and antenna pointing. The typical maintenance methodology in these systems is to load diagnostics from an external media and receive reports on an input/output device. Detailed micro diagnostic routines are entered via the system control panel. The system control panel provides maintenance personnel with an in-depth visibility into the system. Training on these processors invariably consists of detailed instruction on specific equipment design, yielding a specialist on a single piece of equipment.

III. Microprocessors

Microprocessor-based equipments present a special maintenance problem because of the lack of visibility into the system caused by the absence of a control panel. When a failure occurs, internally resident diagnostics report to resident indicators or to a remote device such as an input/output terminal. This system of fault isolation may be satisfactory if the kernel of the device is operational. (The kernel is defined as that part of a system that must be functional for a diagnostic to provide useful results.) The operational procedure to establish a usable kernel is depicted as follows, in order from left to right:



What is desirable for troubleshooting the kernel is a control panel. The Deep Space Network Maintenance Program currently uses a microsystem analyzer which qualifies as an "intelligent control panel" in its simplest application.

The microsystem analyzer requires in-circuit emulation (removing the central processor chip in the unit under test and inserting the analyzer in its place) to take full advantage of its capabilities. This instrument provides front panel visibility into the system, plus the following attributes:

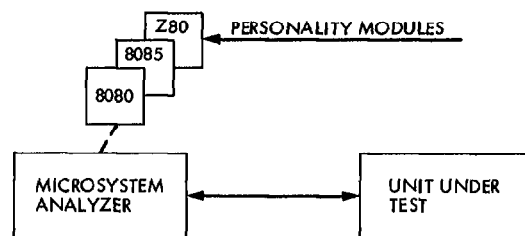
- (1) Signature analysis.
- (2) Time domain analysis.
- (3) Frequency and events counting.
- (4) The ability to execute specially prepared diagnostics nonresident in the unit under test. These nonresident diagnostics may be either in read-only memory or they may be in random access memory which is resident in the test instruments.

Diagnostics resident in a program development system may be downloaded into the test instrument's random access memory and executed to exercise the unit under test.

Support for repair of microprocessor-based assemblies in the Deep Space Network is focused on several pieces of equipment as follows:

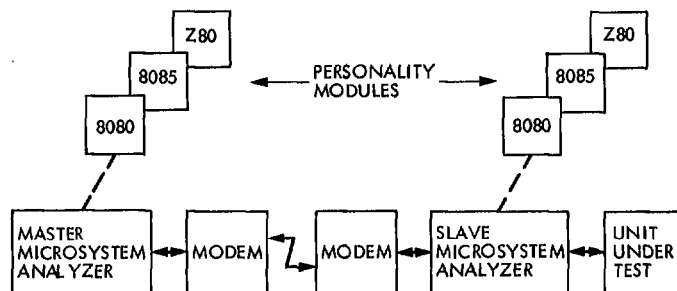
- (1) Diagnostic Program Development System:
Micro/sys DS22
Tektronix LP8200 line printer
Tektronix 4025 display terminal
- (2) Programmable read-only memory programmer
Data I/O system 19
- (3) Portable analyzer
Millenium microsystem analyzer
- (4) Test fixture
Special-purpose to accommodate JPL-designed wire wrap modules.

The following diagrams illustrate the various configurations of the available equipment for the support of microprocessor testing. It should be noted that these devices do not necessarily preclude the need for standard test equipment.



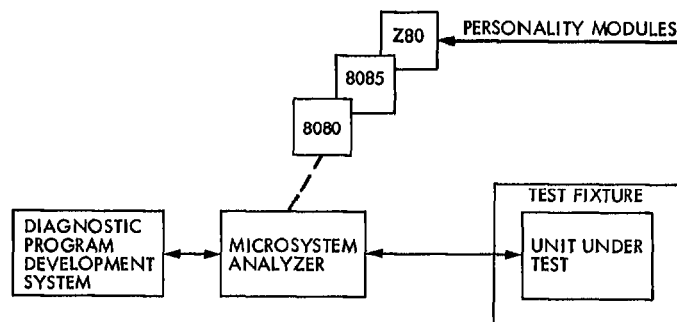
Configuration 1. Portable instrument (local control)

- A. Diagnostics for unit under test are resident in replaceable, programmable read-only memory on the microsystem analyzer.
- B. Diagnostics may be entered manually into the analyzer and executed from either the analyzer or the unit under test.



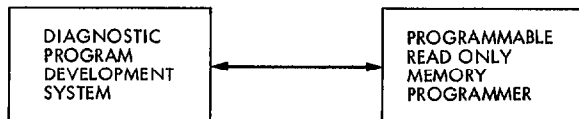
Configuration 2. Portable instrument (remote control)

- A. Same features as Configuration 1 except all control is from the master unit.
- B. Master unit may be resident at some centralized maintenance facility.



Configuration 3. Laboratory instrument

- A. Develop diagnostics which are down-loaded to the microsystem analyzer for exercising the unit under test (may be defective unit returned from field service).
- B. General repair of defective field units.



Configuration 4. Diagnostic development

- A. Down-load diagnostics into PROM Programmer for programming PROMS used in microsystem analyzer.
- B. Generate diagnostic file on floppy disks for distribution to other users.

IV. Conclusions

Current microprocessor support capabilities through in-circuit emulation exist in the Deep Space Network for the following processor chips: 8080, 8085, Z80; this type of testing is thus limited to 8-bit microprocessors. Similar capabilities are being investigated for the support of 16-bit microprocessors. Initial emphasis will be on the support of the 8086 based devices.

Constant training of maintenance personnel will be required to keep abreast of the proliferation of microprocessors. An overall system understanding is essential, with training in the technology of microprocessor-based systems rather than specific detailed equipment design.